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(54) THIN STEEL SHEET SUPERIOR IN COLD DELAYED AGING PROPERTY
AND BAKE HARDENING PROPERTY

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a thin cold-rolled steel sheet superior in cold delayed aging properties and bake hardening properties.

SOLUTION: The thin steel sheet superior in the cold delayed aging properties and the bake hardening properties comprises, by mass%, 0.001-0.2% C, 0.0001-0.2% N, 0.002-0.3% C+N, 0.001-0.1% Si, 0.01-1% Mn, 0.001-0.1% P, 0.05% or less S, 0.001-0.1% Al, 0.001-0.1% Ti, 0.001-0.1% Nb, and the balance Fe with unavoidable impurities, and comprises ultrafine precipitates with diameters of 1-10 nm therein, so as to be as dense as $1 \times 10^{17}/\text{cm}^3$ or higher. In addition, the thin steel sheet preferably contains, by mass%, one or more of 0.005-0.25% Mo, 0.005-1.0% Cr, and 0.005-1.0% W.

[Claim 1]At mass %, it is C : 0.001 to 0.2%, N: 0.0001 to 0.2%, C+N: 0.002-0.3%, Si:0.001-0.1%, Mn : 0.01 to 1%, P:0.001 to 0.1%, S : 0.05% or less, aluminum : [0.001 to 0.1%,] Ti: 0.001-0.1%, Nb : 0.001 to 0.1% is contained, Steel sheets excellent in ordinary temperature resistance to aging which the remainder consists of iron and inevitable impurities, and is characterized by the thing 1-10 nm in diameter included [overly] for a detailed sludge by density a 1×10^{17} individual / more than cm^3 into steel, and baking hardenability.

[Claim 2]Steel sheets excellent in the ordinary temperature resistance to aging according to claim 1 characterized by containing further Mo:0.005-0.25%, Cr:0.005-1.0%, and W:0.005 to 1.0% of one sort, or two sorts or more by mass %, and baking hardenability.

[Claim 3]Steel sheets excellent in the ordinary temperature resistance to aging according to claim 1 or 2, wherein said thing [that a detailed sludge overly consists of any one sort of carbide a nitride, and carbon nitride or two sorts or more], and baking hardenability.

[Claim 4]Steel sheets excellent in the ordinary temperature resistance to aging according to claim 1 or 2, wherein said carbide, a nitride, and carbon nitride are carbide of Ti, a nitride, and carbon nitride, and baking hardenability.

[Detailed Description of the Invention]

[0001]

[Field of the Invention]This invention relates to steel sheets excellent in ordinary temperature resistance to aging and baking hardenability.

[0002]

[Description of the Prior Art]For the body weight saving of a car, reduction of the steel plate board thickness to be used was demanded, and high intensity-ization of the steel plate for cars has been considered. However, high intensity-ization of a steel plate tends to degrade the press-forming nature of a steel plate, and the high-tensile steel sheet excellent in press-forming nature was demanded. As a steel plate which reconciled such press-forming nature and high intensity-ization, the steel plate for paint printing hardening type cars is developed. This steel plate is a steel plate in which yield stress rises by performing paint baking finish which usually includes elevated-temperature maintenance (150 ** - 200 **) after press forming. By making the dissolution C or the dissolution N exist in steel, C or N adheres to the rearrangement introduced at the time of press forming by the heating at high temperature at the time of paint baking processing, movement of a rearrangement is barred, and yield stress rises. The amount of this rise is the amount of printing hardening (the amount of BHs).

[0003]The amount of BHs increases by generally increasing the amount of dissolution C, or the amount of dissolution N. The problem of such a hardening mechanism is at the following point. In order to raise the amount of BHs, if the amount of dissolution C or the amount of dissolution N is increased, a part of rearrangements will already adhere by the dissolution C or the dissolution N in front of shaping (natural aging), and the wavelike surface discontinuity called the stretcher strain by breakdown point elongation at the time of press forming is produced. This makes product characteristics deteriorate remarkably. It was years of technical problem to realize the steel sheets which have the high paint baking hardenability which solved the problem of this natural aging and was excellent in prescription-proof nature.

[0004]JP,5-331553,A and JP,7-300623,A control Nb and aluminum addition, and the method of realizing baking hardenability and prescription-proof nature is indicated. By this method, it is the method of making optimum dose the amount of dissolution N, and the amount of dissolution C, and making prescription-proof nature profitably like, in order to raise the amount of BHs, when the amount of dissolution C is increased, age

deterioration will arise, and the steel which has the high printing hardening characteristic cannot be manufactured. By adding a proper quantity of Mo to JP,2000-17386,A, a stable Mo-C dipole is formed at a room temperature into steel, and the method of acquiring natural-aging nature and baking hardenability simultaneously is indicated. however, a model is proposed about the action of C and N which contribute to these characteristic manifestations -- **** -- the actual condition is having stopped, and there not being sufficient materials design indicator and fully being unable to cope with technical problems, such as realization of further high BH characteristic, and a fall of stoving temperature.

[0005]The method of manufacturing cold rolled sheet steel excellent in prescription-proof nature by making a Nb/C ratio the optimal is indicated by JP,11-229085,A. Although minuteness making of the crystal grain was carried out by carrying out fine dispersion of the NbC and it has said that the amount of grain boundary C is increased, when the amount of printing hardening is raised by this method (amount of BHs >60MPa), breakdown point elongation appears and natural-aging nature is no longer maintained.

[0006]

[Problem(s) to be Solved by the Invention]This invention provides steel sheets excellent in ordinary temperature resistance to aging and baking hardenability in view of such the actual condition.

[0007]

[Means for Solving the Problem]This invention persons by overly fixing in steel by using C or N as a detailed sludge, The place which was made to complete this invention and is made into that gist is as follows by finding out that it can be considered as steel sheets outstanding also in any of ordinary temperature resistance to aging and baking hardenability, and specifying this requirement with which a detailed sludge should overly be filled.

By mass %, (1) C:0.001 to 0.2%, N:0.0001 to 0.2%, C+N: 0.002-0.3%, Si:0.001-0.1%, Mn : 0.01 to 1%, P:0.001 to 0.1%, S:0.05% or less, aluminum : 0.001 to 0.1%, Ti: 0.001-0.1%, Nb : 0.001 to 0.1% is contained, Steel sheets excellent in ordinary temperature resistance to aging which the remainder consists of iron and inevitable impurities, and is characterized by the thing 1-10 nm in diameter included [overly] for a detailed sludge by density a 1×10^{17} individual / more than cm^3 into steel, and baking hardenability.

[0008](2) Steel sheets excellent in ordinary temperature resistance to aging and baking hardenability given in the above (1) characterized by containing further Mo:0.005-0.25%, Cr:0.005-1.0%, and W:0.005 to 1.0% of a kind, or two sorts or more by mass %.

(3) Steel sheets excellent in the above (1), wherein said thing [that a detailed sludge overly consists of any one sort of carbide, a nitride and carbon nitride, or two sorts or more], or ordinary temperature resistance to aging and baking hardenability given in (2).

(4) Steel sheets excellent in ordinary temperature resistance to aging and baking hardenability given in the above (3), wherein said carbide, a nitride, and carbon nitride are carbide of Ti, a nitride, and carbon nitride.

[0009]

[Embodiment of the Invention] 1-10 nm in diameter, and since the target sludge [this invention] is very small, it is overly indicated to be a detailed sludge in distinction from the usual sludge. It is overly thought that detailed sludges are carbide, a nitride, carbon nitride, or these aggregates, and it is not asked whether it is amorphous, it is [whether it is a crystalline substance,] stoichiometric as carbide, a nitride, and carbon nitride, or it is an unfixed ratio. Therefore, it indicates, for example like Ti (N, C) as the carbide, the nitride, carbon nitride, or these aggregates of Ti, and this does not show the composition ratio of Ti, and C and N.

[0010] The feature of this invention is making such C or N that was distributed with high density and that is overly an interstitial atom at a detailed sludge fix (trap). While preventing natural aging in a room temperature and raising the ordinary temperature resistance to aging in a printing hardening die steel plate, it is having also realized high baking hardenability simultaneously by being desorbed from a trap at the paint stoving temperature of 150-200 **, moving to a rearrangement position by diffusion, and making a rearrangement adhere. C and N in ferrite iron have the small degree of dissolution in a room temperature, and a position stable in energy has a tendency which carries out segregation concentration. As this segregation site, crystal defect parts, such as a grain boundary part and a rearrangement part, are mentioned, this invention person used the atom probe field ion microscope (it is written as Atom Probe Field Ion Microscope and following AP-FIM), and did detailed research of this segregation site. As a result, it overly traced that C and N carried out segregation concentration to the detailed sludge. Although it is not overly clear to all the portion of a detailed sludge whether segregation concentration is carried out, one thinks near the interface with matrix iron.

[0011] It depends on sludge size for the amount of C or the amount of N which overly carries out segregation concentration at a detailed sludge. In order to use this segregation C or N for rearrangement adherence, at a room temperature, the trap of C or the N is carried out to a sludge, and it must desorb C or N from a trap site with printing curing temperature. therefore, sludge size has the optimal trap energy -- a detailed sludge becomes overly effective. In order to carry out diffusion supply of C or the N from a trap site, these trap sites exist with high density in steel, and it is necessary to distribute for a lot of rearrangements furthermore introduced by press forming into printing. Therefore, in steel used as a trap site as number density of a detailed sludge, [overly] 1×10^{17} individual / cm^3 is required at least, the number density a 5×10^{17} individual / more than cm^3 is preferred, and the number density a 1×10^{18} individual / more than cm^3 is still more preferred. Since it becomes impossible for C or N which carried out the segregation to it being less than a 1×10^{17} individual / cm^3 at stoving temperature to adhere to a lot of rearrangements introduced by press forming uniformly, prescription-proof nature or baking hardenability falls. Although the maximum of number density is not defined here, since decentralization of the high-density sludge exceeding a 1×10^{20} individual / cm^3 generally will raise steel intensity, a moldability may pose a problem.

[0012] such -- as size of a detailed sludge, 1-10 nm in diameter is overly preferred. If smaller than 1 nm here, it will not become an effective trap site of C or N. On the other hand, if larger than 10 nm, will become a trap site of C or N, but. In order to realize

number density a 1×10^{17} individual / more than cm^3 , so many ingredients will have to be added to steel, and it will be a factor which reduces the moldability of steel remarkably by solid solution strengthening and dispersion strengthening, although the kind of detailed sludge is not overly limited in this invention, it uses as a trap site of C or N -- as a detailed sludge, carbide, a nitride, carbon nitride, or these mixtures are overly preferred. This is for C and N tending to carry out fine dispersion of the carbide, a nitride, and the carbon nitride, since the diffusion coefficient is large, and being easy to use them effectively as a trap site of C or N.

[0013] Carbide, a nitride, and carbon nitride have carbide of Ti, a nitride, and the most preferred carbon nitride. The reason is 1-10 nm [which has trap energy with suitable Ti] for making a detailed sludge overly easy to form. The reason for ingredient limitation in this invention is as follows. % expresses mass %. When C and N make baking hardenability reveal, they are an important element, and it is indispensable that 0.002% or more of the amount of C+N contains. However, since it would become difficult for the amount of dissolution to secure increase and natural-aging nature if there are too many amounts of C+N, the maximum was made into 0.3%.

[0014] They could be C:0.001% or more and N:0.0001% or more because the reduction to less than [this] not only becomes a great cost hike in steel manufacture, but was not able to acquire high baking hardenability. It is because [which furthermore consists of a carbon thing and a nitride] it becomes impossible overly to make a detailed sludge from high density. On the other hand, if these values were exceeded, in order that intensity might become high too much and might spoil processability, they could be C:0.2% or less and N:0.2% or less. Mn, Si, and P are fundamental components which are not made to write in order to obtain the intensity needed as steel sheets. Mn: 0.01%, Si: If less than 0.001% and P:0.001%, intensity runs short. Mn: 1%, Si: If it exceeds 0.1% and P:0.1%, in order that intensity may become high too much and may spoil processability, let these be upper limit.

[0015] Since S may cause the embrittlement between what is called heat which causes red heat embrittlement at the time of hot-rolling, and breaks on the surface when it exceeds 0.05%, it is 0.05% or less. aluminum is an element required as a deoxidizer and is required 0.001% or more, and if it added exceeding it, in order that intensity might become high and might spoil processability, it could be 0.1% or less. Ti is one of the elements of this invention which can overly be used for formation of a detailed sludge, and in order to fix superfluous C, N, and S and to secure prescription nature, it is required 0.001% or more. The maximum was made into 0.1% in order for recrystallizing temperature to rise and to cause degradation of processability again, if it adds exceeding it.

[0016] Nb as well as Ti is one of the elements of this invention which can overly be used for formation of a detailed sludge. The minimum was made into 0.001% because it became difficult to secure prescription nature less than [it], and the maximum was made into 0.1% in order for recrystallizing temperature to rise and to cause degradation of processability again, if it adds exceeding it. Mo, Cr, and W have an effect to which fine

dispersion of the sludge in steel is carried out, although the details of the mechanism are not clear. That is, the conditions for [of this invention] overly forming a detailed sludge can be eased by adding these one sort or two sorts or more. The minimum of the addition of each element was made into 0.005% because this effect was not acquired less than [it], it carried out about Mo and the maximum was made into 1.0% about Cr and W 0.25%, in order that intensity became high, and it not only spoils processability, but alloy cost might go up since it is expensive if it is exceeded.

[0017]In steel, 1-10 nm in diameter in order to make the number density a 1×10^{17} individual / more than cm^3 overly distribute a detailed sludge, it is realizable by annealing, for example on specific conditions. The size of the carbide or the nitride which deposits if the cooling rate of annealing is generally made late becomes large, and number density becomes small. The size of the carbide or the nitride which deposits if a cooling rate is enlarged on the contrary becomes small, and number density becomes large. However, since the amount of dissolution of C or N increases in this case, suitable overaging treatment (OA) becomes effective. In order overly to distribute a detailed sludge with high density, it is necessary to select annealing conditions with the ingredient and concentration in steel.

[0018]For example, as a desirable manufacturing method, it is possible by limiting annealing conditions after casting rolling. After holding annealing below at not less than 800 °C Ac_3 temperature, it is cooled with the cooling rate at 10-100 °C/s. Holding in temperature of not less than 800 °C in order to make C and N once dissolve, it will remain in the form of the usual sludge with less than this temperature. In order to avoid a transformation, below Ac_3 temperature carries out. The retention time of 1 minutes or more is preferred in order to acquire sufficient effect. If less than s in 10^{-2} /, the size of a sludge will become easy to exceed 10 nm, and a cooling rate is having dissolved with as, when s's was exceeded in 10^2 / on the other hand, and becomes difficult to produce a sludge.

[0019]As mentioned above, although it is general, and is desirable and manufacturing method ***** explanation was given, since the conditions which manufacture the steel plate of this invention by a steel composition -- there is an effect which eases this condition in Mo as above-mentioned -- differ, it is desirable [conditions] to become final and conclusive a manufacturing method based on the result analyzed by AP-FIM. Analysis of the atomic existence state using AP-FIM is conducted as follows. This device can investigate an atomic existence gestalt unobservable in a transmission electron microscope (TEM) with the resolution of a crystalline-lattice level. By impressing high tension to the sample which carried out needlelike polishing work, and measuring the time of flight of the ion which carried out electric field evaporation, it asks for mass to charge ratio, and a composition atom is determined. Thereby, the presentation of the sludge in steel, a segregation atom, etc. can be investigated correctly. Furthermore, the existence position in steel can also be simultaneously determined from the order of incorporation of measurement data.

[0020]The rudder chart showed an example as a result of the matrix measurement within a grain in the cold rolled sheet steel manufactured by this invention to drawing 1. A horizontal axis expresses a detection atom total and the vertical axis expresses the number of addition of the target atom with the rudder chart. Therefore, inclination of a graph is equivalent to the concentration of the target atom, and inclination becomes large in the portion which carried out segregation concentration (figure Nakaya seal). Since a horizontal axis corresponds in order of detection ion incorporation, it will express the depth position (space coordinates) of a sample. It turns out that C atom overly forms the detailed sludge with TiN and Ti. in the steel plate which the outstanding prescription-proof nature revealed, it distributed a 1×10^{17} individual / more than cm^3 in the grain -- the detailed sludge was overly observed.

[0021]the mean number density of the detailed sludge performed matrix measurement of the arbitrary direction many times, and was overly observed in it -- it overly asked from the number of detailed sludges. AP-FIM means that the measurement region in one-time measurement is small, and the number density is low when a detailed sludge is not overly observed. When the atomic number which can be measured by one measurement considers it as a 1×10^5 individual and detailed deposit density is overly less than a 1×10^{17} individual / cm^3 , in the measurement which is several AP-FIM, it becomes difficult overly to observe a detailed sludge automatically probable. Therefore, when a detailed sludge is not overly observed by matrix measurement of the arbitrary direction by AP-FIM, mean density is judged to be less than a 1×10^{17} individual / cm^3 . In TEM, since the observation area is large, the sludge of low density can be investigated more, but as for a detailed sludge, 10 nm or less overly becomes observation difficulty from a point of resolution in many cases.

[0022]Deposit part size can be estimated from the atomic number which constitutes the sludge. Although an atom evaporates for every atomic layer by electric field evaporation and one atomic layer measured is dependent on probe hole size, crystal face orientation, a needle sample tip curvature radius, etc., generally it is equivalent to 50-200 atoms (light metal (1992) P236-247). Sludge size can be estimated by investigating what atomic layer the sludge has attained to. For example, in drawing 1, about 10 atomic layers are attained to and it can be regarded as an about 2-nm sludge.

[0023]Evaluation of prescription nature and baking hardenability is performed as follows. Although natural-aging nature could be held in 40 ** atmosphere on the 70th, and could do the tensile test and it could investigate by measuring the breakdown point elongation (YP-EI) at this time, the artificial accelerated test of 100 **x 1 hour estimated prescription-proof nature instead here. This YP-EI value made 0.4% or less good. Measurement of baking hardenability measured yield stress (YP) after holding steel sheets by 170 ** of tension 2% for 20 minutes, and evaluated it as the strong difference of BHs, i.e., amount, when a tensile test is done 2% previously. Either hot rolled sheet steel or cold rolled sheet steel is OK as the steel sheets of this invention. Furthermore, a hot rolling process and a cold rolling process in particular are not limited. Next, although an example explains the operation effect of this invention still more concretely, they are

for illustration only and this invention is not unfairly restricted by it.

[0024]

[Example]The test specimen which has the chemical composition indicated to Table 1 was ingoted. % of a chemical entity expresses mass %.

[0025]

[Table 1]

鋼種	化学成分(質量%)											
	C	Si	Mn	P	S	sol. Al	N	Ti	Nb	Mo	Cr	W
a	0.0037	0.037	0.5	0.032	0.007	0.043	0.002	0.007	0.003	0.134	—	—
b	0.0041	0.037	0.5	0.032	0.007	0.043	0.0019	0.007	0.003	0.052	—	—
c	0.0037	0.037	0.5	0.032	0.007	0.043	0.002	0.007	0.003	—	—	—
d	0.0020	0.036	0.5	0.031	0.007	0.045	0.0018	0.007	0.002	0.055	—	—
e	0.0020	0.036	0.5	0.031	0.007	0.045	0.0018	0.007	0.002	—	—	—
f	0.0061	0.040	0.51	0.032	0.009	0.042	0.0018	0.007	0.003	0.204	—	—
g	0.0061	0.040	0.51	0.032	0.009	0.042	0.0018	0.007	0.003	—	—	—
h	0.0038	0.040	0.51	0.032	0.007	0.042	0.002	0.007	0.003	—	0.25	0.12

$$*ex.C = C - (12/93)Nb - (12/48)(Ti - (48/14)N)$$

[0026]On the conditions indicated to Table 2, hot-rolling and cold rolling were performed, and it annealed after that, and was considered as cold rolled sheet steel.

[0027]

[Table 2]

製造条件	熱延条件			冷延条件	焼鈍条件		
	加熱温度 ℃	仕上温度 ℃	巻取温度 ℃	圧下率 %	温度 ℃	冷却速度 ℃/s	OA ℃×秒
A	1100	900	700	80	820	10	なし
B	1150	900	650	70	800	20	なし
C	1100	900	800	80	820	50	なし
D	1100	900	700	70	820	100	なし
E	1100	900	700	80	820	100	350×60
F	1100	900	700	80	800	100	350×180
G	1150	900	650	80	820	100	400×80

[0028]The result of a mechanical test is shown in Table 3. ex.C is the value which deducted the quantity deposited by Ti and Nb from the amount of addition C here, and it estimated by the formula shown in the table.

[0029]

[Table 3]

鋼板	鋼種	製造条件	超微細析出物 数密度 (個/cm ²)	BH特性		耐時劣性		備考
				BH量 M/Pa	評価	降伏点伸び %	評価	
1	c	A	観察されず	72	○	1.12	×	比較例
2	c	B	観察されず	74	○	1.5	×	比較例
3	c	C	観察されず	81	○	1.26	×	比較例
4	c	D	観察されず	86	○	0.86	×	比較例
5	c	E	5x10 ¹⁷	71	○	0.18	○	本発明例
6	c	F	観察されず	70	○	0.82	×	比較例
7	c	G	観察されず	65	○	1.00	×	比較例
8	e	E	1x10 ¹⁷	37	△	0.28	○	本発明例
9	e	G	観察されず	32	×	0.60	×	比較例
10	a	B	1x10 ¹⁸	72	○	0.08	○	本発明例
11	b	B	5x10 ¹⁷	80	○	0.28	○	本発明例
12	c	B	観察されず	70	○	1.21	×	比較例
13	d	B	2x10 ¹⁷	38	△	0.10	○	本発明例
14	e	B	観察されず	32	×	0.70	×	比較例
15	f	B	2x10 ¹⁷	90	○	0.38	○	本発明例
16	g	B	観察されず	86	○	1.36	×	比較例
17	h	B	5x10 ¹⁷	71	○	0.30	○	本発明例
18	a	D	観察されず	80	○	1.30	×	比較例
19	a	G	2x10 ¹⁷	72	○	0.39	○	本発明例

[0030](Example 1) The steel types c and e of Table 1 were used, and cold rolled sheet steel was manufactured by each manufacturing conditions indicated to Table 2. The finishing temperature of hot-rolling was 900 **, and rolling-up temperature was 600-700 **. The cold rolling rate was made into 70 to 80%, and was cold-rolled to 0.8-mm thickness. The annealing process for 3 minutes was performed at 800-820 ** after cold rolling, and it was made to cool with various cooling rates. Overaging treatment (OA) was performed about the thing of further some. 1% of temper rolling was performed to the annealed steel plate, and it was considered as cold rolled sheet steel. it investigated by the result of the mechanical property of the steel plate (steel plates 1-9) manufactured to Table 3, and AP-FIM -- the mean number density of a detailed sludge is overly shown. setting to the manufacturing conditions (steel plate 5) of E in the steel type c -- a 5x10¹⁷ individual / cm³ -- the detailed sludge was overly observed and good BH characteristic and prescription-proof nature were shown simultaneously. Also in the steel type e, on the manufacturing conditions of E, the detailed sludge was overly observed and good prescription-proof nature was shown. In the other conditions, size was deposit density is low or as large as more than 10 nm, and although the amount of BHs was good, prescription-proof nature was not good. On the manufacturing conditions of E of high density by which the detailed sludge was overly observed, BH characteristic and the prescription-proof characteristic were most excellent.

[0031]When this manufactures the steel of high number density which overly distributed the detailed sludge, high BH characteristic and the outstanding prescription-proof nature are simultaneously realizable.

(Example 2) Let the steel (steel type a-h) by which quality governing was carried out as

shown in Table 1 be cold rolled sheet steel according to the manufacturing conditions B of Table 2 (steel plates 10-17). The finishing temperature of hot-rolling was 900 **, and rolling-up temperature was 650 **. The cold rolling rate was made into 70%, and was cold-rolled to 0.8-mm thickness. The annealing process for 1 minute was performed at 800 ** after cold rolling. 1% of temper rolling was performed to the annealed steel plate, and it was considered as cold rolled sheet steel.

[0032]In Table 3, the YP-EI value for prescription-proof nature evaluation was investigated by progressive aging of 100 **x 1 hour. In steel with many amounts of ex.C, BH value has appeared highly, and high BH value of 60 or more MPa is obtained for ex.C with 0.003% or more of steel. If breakdown point elongation estimates the prescription-proof nature of these steel, the prescription-proof nature which was excellent in Mo about enough steel plates 10 and 15 which carried out quantity addition is shown. Prescription-proof nature is shown also in the steel plates 11 and 13 which added a little Mo, and the steel plate 17 which added Cr and W further. On the other hand, in the steel plates 12, 14, and 16 which made Mo additive-free, big breakdown point elongation has appeared and prescription-proof nature is not obtained. Since the detailed sludge overly observed by AP-FIM in steel to the steel plate in which resistance to aging was shown, it is thought that this influenced resistance to aging.

[0033]It has the same amount of C as the steel plate 10 which added C 0.0037% 0.134% and manufactured Mo by the manufacturing conditions B, and detailed comparison was performed about the Mo additive-free steel plate 12. In the case of the steel plate 10, detailed sludge number density is over a 1×10^{18} individual / cm^3 , and the amount of BHs was over 60MPa, but breakdown point elongation showed 0.1% or less and very good ordinary temperature resistance to aging. On the other hand, although detailed sludge number density was not overly observed (judged as less than a 1×10^{17} individual / cm^3) but the amount of BHs was over 60MPa in the steel plate 12, a YP-EI value is 1.0% or more, and ordinary temperature resistance to aging was not seen. In this steel, the stretcher strain appeared at the time of press working of sheet metal.

[0034]it was observed by AP-FIM in the steel plate 10 which showed good baking hardenability and ordinary temperature resistance to aging in Table 4 -- the example of the atomic composition of a detailed sludge is overly shown.

[0035]

[Table 4]

クラスターNo	検出原子数			偏析C数
	C	N	Ti	C-(Ti-N)
#1	1	1	2	0
#2	19	12	17	14
#3	10	4	7	7
#4	40	19	23	36
#5	2	1	2	1
#6	18	5	11	12

[0036]The detailed sludge overly consisted of the Kazuhara child to a tens of atoms complex of C, and Ti and N, and the size was several nanometers or less. When the presentation was investigated, C atomic number increased more than {(the number of Ti atoms) - (N atomic number)}, and existence of the surplus C was shown. namely, -- this - super- -- a detailed sludge -- TiN or TiC -- C overly carries out segregation concentration at a detailed sludge. It turned out [which the amount of C which carried out the segregation becomes from more than an atom more than ten depending on the size of Ti (N, C)] that the surplus C overly exists in tens of atom or more excess in a detailed sludge. In AP-FIM, since the detection ratio of ion is about 60%, a actual atomic number increases more than this. Furthermore, since a TiC sludge generally has the presentation of TiC_x ($x < 1$), the amount of surplus C will have been underestimated here.

[0037]On the other hand, when the amount of dissolution C was investigated by AP-FIM measurement, below 0.0005 mass % became with average concentration, and it turned out that many of C contained in steel is overly carrying out segregation concentration at the detailed sludge. Next, **** prestrain was impressed to this steel plate 10 2%, and the observation same about the sample which carried out printing hardening for 170 **x 20 minutes was performed. However, excessive C was not measured overly stoichiometrically to a detailed sludge. That is, C which overly carried out segregation concentration at the detailed sludge is a printing hardening process, is diffused in a rearrangement, and is considered to have become the supply origin of rearrangement adherence (Cottrell atmosphere formation).

[0038]On the other hand, although observation with the same said of the test specimen (steel plate 12) which does not add Mo was tried, a detailed sludge was not overly observed in steel by the matrix measurement by AP-FIM. This means that the number density of a sludge is less than a 1×10^{17} individual / cm^3 . When TEM observation was performed, not less than 50-nm comparatively large-sized Ti (N, C) sludge was observed, but by mean number density, it was below a 1×10^{12} individual / cm^3 . Next, detailed comparison was performed about the steel plate 18 manufactured by the manufacturing conditions D about the steel type a which added Mo enough, and the steel plate 19 manufactured by the manufacturing conditions G. In the steel plate 18 manufactured by the conditions D, although outstanding BH characteristic was shown, prescription-proof nature is inferior, and the detailed sludge was not overly observed. On the other hand, in the steel plate 19 manufactured by the conditions G of the same steel type, BH characteristic and prescription-proof nature were good, and detailed sludge number density was overly a 2×10^{17} individual / cm^3 . These results show that Mo addition extends the range of the manufacturing conditions of the steel plate which has outstanding BH characteristic and the outstanding prescription-proof nature.

[0039]Having prevented natural aging, having adhered the rearrangement by C or N which seceded from the trap with printing curing temperature, and having strengthened steel with overly distributing a detailed sludge with high density in steel, and making them carry out segregation concentration of C or the N from the above experiment was shown. When this manufactures the steel of high number density which overly distributed the detailed sludge, high BH characteristic and the outstanding prescription-proof nature

are simultaneously realizable.

[0040]

[Effect of the Invention]The steel sheets which were excellent in ordinary temperature
***** and baking hardenability by this invention are provided, and it can be said that
the industrial value is very high.